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Influence of pre-slaughter transportation and capture chase stress on carcass and meat quality of indigenous chicken reared under traditional system in Benin

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Abstract

Stress generally deteriorates meat quality. The current study aims to evaluate the influence of transportation and capture chase pre-slaughter stress on carcass and meat quality in local chicken of Benin. Sixty chickens of 8 to 10 months old divided into 3 flocks of 10 males and 10 females reared under traditional system were used. Chickens of the first flock were slaughtered after one hour of transportation by motorcycle, those of the second flock after 10 minutes of capture chase and the third one without pre-slaughter stress. Carcass and meat quality was evaluated. Carcass quality traits didn't vary according to the pre-slaughter stress, except the thigh-drumstick weight that was higher with chased and transported chickens ($P < 0.05$). Breast and thigh meat pH values of stressed chickens were higher ($p < 0.001$). Drip loss and cooking loss didn't vary between flocks. Meat lightness was lower for the breast and the thigh of transported chickens on the slaughter day and at 24 hours *post mortem* ($P < 0.001$). It was also lower in the thigh of the chased chickens at 24 hours after slaughter. The breast meat of stressed chickens was redder whereas their thigh meat showed the lowest values of the yellow index b * only at 24 hours. The meat shear force was the same for the three groups. The flavor, the juiciness, the tenderness and the global acceptance of the breast meat of the chickens didn't vary. Then, transportation and capture chase reduce the sensory and technological meat qualities of indigenous chicken.

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Introduction

Stress can be considered as the reaction of the organism or the biological response to stimuli that disturb its normal physiological equilibrium or homeostasis (Lara *et al.*, 2013). This response results in the increasing of poultry plasma corticosterone concentration. According to Selye (1976), stress is a nonspecific response of the body to any demand whereas the stressor is an agent that produces stress at any time.

For animals destined to slaughter, the environmental conditions, the capture, the manipulations, the transportation, the feed withdrawal are some stress factors that can have consequences on the production (Lara *et al.*, 2013), animal welfare (Voslarova *et al.*, 2007) and on carcass and meat quality (Radu *et al.*, 2012). But genetics and biotope can affect the extent of these consequences. Genetics can explain 40% to 50% of the variability of breast ultimate pH observed within a population (Le Bihan-Duval *et al.*, 2001& 2008; Chabault *et al.*, 2012).

Researchers are already working on how to control carcass and meat quality changings due to pre-slaughter stress factors across America, Europe, Asia and North Africa (Zhang *et al.*, 2014; Perai *et al.*, 2014) where, the consequences of these factors on their genetic resources are already known. Meanwhile, the influence of local pre-slaughter conditions stress on indigenous chicken carcass and meat quality is less investigated in West Africa in general and in Benin in particular. Or, the indigenous chickens slaughtered come from the traditional system characterized by the quasi absence or the precariousness of habitats. Birds are chased to be catch before slaughter. Others are slaughtered after an important transportation. This study aims to evaluate the influence of transportation and capture chase pre-slaughter stress on carcass and meat quality in local chicken of Benin.

Materiels and methods

Area of study

The study was carried out in the Laboratory of Animal Biotechnology and Meat Technology of the Department of Animal Production and Health of the Polytechnic School of Abomey-Calavi.

The chickens used were produced under traditional breeding system in Abomey-Calavi. This area benefits from climatic conditions of subequatorial type characterized by two rainy seasons with an uneven spatial and temporal repartition of rainfall (the major, from April to July and the minor, from September to November). These seasons are separated by two dry seasons. Average rainfall is close to 1200 mm per year. The monthly average temperatures vary between 27°C and 31°C. The relative air humidity fluctuates between 65% from January to March and 97% from June to July.

Birds rearing and sampling

Sixty (60) local chickens of eight to ten months old produced from two (2) roosters and ten (10) hens all of South ecotype of Benin were used. These birds were reared under traditional breeding system where, they have a habitat for night housing or protection against bad weather and a course of 400 m². They fed themselves around and also received grains, agricultural by-products and kitchen rests. Birds were vaccinated against fowl pox and Newcastle disease. On the eve of the slaughter day, chickens were divided into three homogeneous flocks of 10 males and 10 females each.

Pre-slaughter conditions, slaughter process and carcass cutting

The birds of the flock 1 have been attached on legs and kept until the following day morning where, they were slaughtered immediately after one hour of motorcycle transportation on 25 km. While transporting, they were hung behind to motorcycle upside down. Flock 2 birds were kept in a local of 48 m² until the following day where, they had been chased for 10 minutes and caught in this local and slaughtered without resting time. The one of the flock 3 were the control chickens and didn't undergo any stress before slaughter. Birds were weighted and bled by section of the jugular vein. After slaughter, chickens were scalded in a hot water (75°C) and plucked manually. Legs have been sectioned at the tibio-tarsusmetastasal joint level. The head were separated from the neck at the skull-atlas junction. The abdominal and thoracic cavities organs were taken off. Hot carcasses have been weighted and immediately cut.

Data collection

Live weight before slaughter, hot carcass weight and carcass cuts weight (breast, wings, thigh-drumstick) were registered. Carcass yield was determined from the live weight and the percentage of each carcass cut from the hot carcass weight.

The pH was measured in the right slice of the breast muscle (*Pectoralis major*) and in the right thigh muscle (*Iliotibialis superficialis*) at 2 cm depth with a portable pH-meter (HANNA Instrument R, Italy) provided with a specialized probe and a temperature control system. The measures were taken at 1h, 12h, 24h and 48h after slaughter. For every measure, 5 repetitions were performed. On each measure day, the pH-meter has been calibrated previously with two buffers pH-meter, pH 4 and pH 7 following a procedure described by the manufacturer.

The drip loss was determined with the left slice of the breast muscle according to the procedure described by Honikel (1987). Each sample was suspended to a hook, put into a refrigeration bag without touching its bottom. After 24 hours at 4°C in hung position, the samples were taken out of the bag without touching the bottom that contains the draining juice. They were mopped, weighted and drip loss was calculated as the percentage of weight loss during the storage.

Each sample weighted was put into a bag and manually sealed without storing air. They were put in a bain-marie, cooked until the core temperature reached 75°C. Then, samples were removed, cooled to room temperature, mopped, reweighted and cooking loss was calculated as the percentage of weight loss during the cooking process.

The meat color was determined using a Minolta Chromameter CR-400 (Japan) in the trichromatic system (CIE L*a*b *) after storage of the samples at 4°C during 1 h 30 min. This is based on three dimensional space with one dimension for luminance (L* is the lightness) and two for color a* (redness) and b * (yellowness) (Zhang and Barbut, 2005). The chroma (C) and the hue angle (h) were determined as followed: $C = (a^{*2} + b^{*2})^{1/2}$ and $h = \tan^{-1} b^*/a^*$. For each measure, 5 repetitions were performed.

The measures were taken on the ventral face, at the third superior on the thickest part of the breast muscle left slice and on the middle of the ventral face of the left thigh muscle. The Minolta was calibrated using standard color tiles. The color was measured on the slaughter day and at 24 hours *post mortem*.

The samples prepared for the cooking loss determination were subsequently used for the Warner-Bratzler shear force analysis according to Bratcher *et al.* (2005). Cores with a diameter of 1.27cm were removed from the sample at different positions parallel to fiber orientation (longitudinal axis of the myofibres) and sheared as described by Honikel (1998). Shear force determinations were conducted on a texture analyzer LF plus (LLOYD Instruments) equipped with a Warner-Bratzler shear force head vertical to the fiber direction. The Warner-Bratzler single blade was used. The shear velocity was 200 mm/min. Each value was an average of at least 5 repetitions.

The right slice of the *Pectoralis major* of each chicken was used for the sensory analysis. The samples were put in cooking bags separately without seasoning and boiled in a bain-marie until the meat core temperature reached 75°C. A trained jury of 10 members was used for the test. After cooling to room temperature, each sample of meat cooked was cut into ten identical pieces at least. Every judge received in a plate divided by the manufacturer in three parts of different colors a piece of each category and each flock of chicken and filled in a recapitulative results form. In total, six samples of which two by flock (one from a male and one from a female) were put by turn in the plate under numbers 1 to 6. The judges have appreciated the tenderness, the juiciness, the flavor and the global acceptance of the meat under marks going from 1 to 5.

Statistical analysis

The data collected on carcass and meat quality were analyzed using the software SAS (Statistical Analysis System, 2006). The General Linear Model procedure was used for the variance analysis. The Fisher test was used to test the significance of stress and sex effects on carcass and meat quality traits. Means were compared pairwise by the Student test.

Results

Carcass traits of indigenous chicken according to the pre-slaughter stress

Carcass traits are given by pre-slaughter stress in Table 1. The bird live weight of each pre-slaughter stress flock was similar. The same tendency was observed for the hot carcass weight, the breast weight, the thigh-drumstick weight and for the wings weight. The hot carcass yield didn't even statistically vary. The yields of the breast and of the wings were also the same. However, the yield of the thigh-drumstick of the stressed chickens was higher than the one of the control birds (P<0,001). The carcass traits of males and of females by flock are presented in the Table 2. No significant variation was observed for all the parameters studied from one sex to the other.

Table 1. Carcass traits, drip loss, shear force and sensory quality of the *Pectoralis major* of indigenous chicken according to the pre-slaughter stress.

Variable	Control birds	Chased birds	Transported birds	Standard Error	Anova
Live weight (g)	912.50a	888.00a	887.50a	25.17	NS
Hot carcass weight (g)	625.00a	599.00a	620.00a	15.10	NS
Breast weight (g)	141.02a	128.58a	136.18a	5.15	NS
Thigh-drumustick weight (g)	190.83a	198.69a	198.56a	6.62	NS
Wings weight (g)	82.40a	77.18a	75.24a	3.40	NS
Hot carcass yield (%)	68.59a	67.86a	70.12a	0.94	NS
Breast yield (%)	22.53a	21.31a	21.95a	0.53	NS
Thigh-drumustick yield (%)	30.54b	33.18a	31.99a	0.72	*
Wings yield (%)	13.22a	12.96a	12.16a	0.54	NS
Drip loss (%)	3.25a	3.13a	2.78a	0.69	NS
Cooking loss (%)	8.20a	7.86a	7.28a	0.70	NS
Shear force (N/cm^2)	56.88a	58.41a	56.60a	1.14	NS
Flavor	2.96a	2.96a	3.00a	0.06	NS
Juiciness	2.85a	2.78a	2.93a	0.05	NS
Tenderness	3.10a	3.00a	3.11a	0.06	NS
Global Acceptance	3.11a	3.02a	3.12a	0.05	NS

NS: P > 0.05; *: P <0.05; ANOVA: Analysis of Variance; Means of the same line followed by different letters differ significantly at the threshold of 5%.

Variation of pH, drip loss and cooking loss

The variation of the pH according to the pre-slaughter stress is given in the Table 3. The pH of the breast and of the thigh muscles of chickens stressed by the transportation or by the capture chase was superior to the one of non-stressed chickens at all measure times (P <0.001). The breast pH of chased birds was higher than the one of the transported chickens at 1 hour. The same tendency was observed for the pH measured in the thigh at 12, 24 and 48 hours after slaughter. On the contrary, no difference was registered for the pH measured at the other times in the two muscles for both stressed chickens. The variation of the pH of males and of females of the three flocks is presented in the Table 4. For the control group, the males thigh pH was higher than the one of the females at 48 hours *post mortem* (p <0.05). It was so in the breast of the chased birds at 12 hours after slaughter. Similar results was even found among the transported birds for the breast at 12h, 24h and 48h *post mortem* but only at 12h and 48h with the thigh muscle. However, during the other times no difference was noticed between sexes for the pH of the different flocks. Besides, for the different flocks, the most important pH fall was observed in the two muscles during the first twelve hours *post mortem* (Fig. 1 & 2). The drip loss was statistically similar for the three groups of chickens.

Table 2. Carcass traits, drip loss, shear force and sensory quality of the *Pectoralis major* of males and females of the indigenous chicken according to the pre-slaughter stress.

Variable	Control birds		Chased birds		Transported birds		Standard Error	ANOVA
	Female	Male	Female	Male	Female	Male		
Live weight (g)	910.00a	915.00a	858.00a	918.00a	868.00a	907.00a	35.92	NS
Hot carcass weight (g)	627.00a	623.00a	589.00a	609.00a	616.00a	625.00a	21.83	NS
Breast weight (g)	146.47a	135.58a	132.55a	124.61a	146.98a	125.39a	7.08	NS
Thigh-drumustick weight (g)	180.04a	201.62a	188.58a	208.8a	186.78a	210.34a	8.91	NS
Wings weight (g)	84.17a	80.63a	77.00a	77.37a	73.71a	76.77a	4.92	NS
Hot carcass yield (%)	69.04a	68.14a	68.87a	66.84a	71.16a	69.08a	1.34	NS
Breast yield (%)	23.34a	21.71a	22.4a	20.22a	23.82a	20.07a	0.64	NS
Thigh-drumustick yield (%)	28.67a	32.41a	32.17a	34.18a	30.35a	33.63a	0.92	NS
Wings yield (%)	13.47a	12.97a	13.12a	12.80a	11.98a	12.34a	0.78	NS
Drip loss (%)	3.82a	2.69a	3.35a	2.90a	2.88a	2.69a	0.94	NS
Cooking loss (%)	8.59a	7.81a	9.60a	6.13a	7.84a	6.72a	0.95	NS
Shear force (N/cm^2)	58.96a	54.79a	58.45a	58.37a	54.22b	58.97a	1.60	*
Flavor	3.05a	2.87a	3.01a	2.91a	3.02a	2.99a	0.08	NS
Juiciness	2.82a	2.88a	2.82a	2.75a	2.88a	2.99a	0.07	NS
Tenderness	3.08a	3.13a	3.04a	2.96a	3.15a	3.08a	0.08	NS
Global Acceptance	3.11a	3.11a	3.07a	2.96a	3.11a	3.13a	0.07	NS

NS: P > 0.05;*: P < 0.05; ANOVA: Analysis of Variance; Means between the classes of the same line followed by different letters differ significantly at the threshold of 5%.

This same tendency was observed for the cooking loss (Table 1).

They didn't even vary between sexes (Table 2). Nevertheless, females showed the important proportions.

Color of the Pectoralis major and of the Iliotibialis superficalis muscles

Color traits on the slaughter day and at 24 hours *post mortem* are presented in Table 5. For both breast and thigh meats, the lightness was the same for the control and chased chickens at these times but the smallest with the transported birds (P <0,001).

However, it was similar in the thigh of chased and transported chickens at 24 hours *post mortem*. The red index a* was lower in the thigh of the chased chickens on the slaughter day (P <0,001) but similar for the three flocks 24 hours after. In the breast it was lower with control chickens at the two moments.

The red index of this muscle was similar for both stressed groups on the slaughter day but higher with the chased birds the following day (P <0,001).

In general, the red index measured in the breast meat of stressed poultry was higher.

The yellow index b* registered in the thigh was identical for the stressed and the control chickens on the slaughter day but lower with the stressed one at 24 hours *post mortem*. The one of the breast was higher in chased chickens on the slaughter day followed respectively by those of the control and the transported birds. These last two groups showed similar values at 24 hours *post mortem*.

The hue angle was higher in the thigh of the transported chickens on the slaughter day (P <0.01). It was higher in the chased than in the control chickens at 24 hours *post mortem* but similar in the stressed one at this moment.

In the breast meat, the hue angle was identical for stressed and unstressed chickens on the slaughter day and at 24 hours *post mortem*.

Table 3. Breast and thigh muscles pH of indigenous chicken according to the pre-slaughter stress.

Moment (hour)	Variable	Control birds	Chased birds	Transported birds	Standard Error	ANOVA
1	Breast pH	6.25c	6.48a	6.41b	0.02	***
	Thigh pH	6.37b	6.66a	6.63a	0.01	***
12	Breast pH	5.74b	5.93a	5.92a	0.03	***
	Thigh pH	5.93c	6.38a	6.23b	0.03	***
24	Breast pH	5.69b	5.89a	5.85a	0.02	***
	Thigh pH	5.87c	6.33a	6.21b	0.02	***
48	Breast pH	5.72b	5.90a	5.84a	0.02	***
	Thigh pH	5.88c	6.33a	6.15b	0.02	***

*** : P < 0.001 ; ANOVA : Analysis of Variance; Means of the same line followed by different letters differ significantly at the threshold of 5%

Table 4. Breast and thigh muscles pH of males and females of the indigenous chicken according to the pre-slaughter stress.

Moment (hour)	Variable	Control birds		Chased birds		Transported birds		Standard Error	ANOVA
		Female	Male	Female	Male	Female	Male		
1	Breast pH	6.12a	6.37a	6.39a	6.58a	6.33a	6.50a	0.02	NS
	Thigh pH	6.33a	6.41a	6.64a	6.69a	6.59a	6.67a	0.02	NS
12	Breast pH	5.77a	5.70a	5.87b	5.99a	5.81b	6.03a	0.04	**
	Thigh pH	5.93a	5.93a	6.38a	6.39a	6.17b	6.30a	0.04	*
24	Breast pH	5.68a	5.71a	5.85a	5.92a	5.74b	5.95a	0.03	*
	Thigh pH	5.81a	5.93a	6.33a	6.34a	6.17a	6.24a	0.04	NS
48	Breast pH	5.70a	5.73a	5.87a	5.94a	5.74b	5.95a	0.03	*
	Thigh pH	5.83b	5.94a	6.33a	6.34a	6.10b	6.20a	0.03	*

: P > 0.05; *: P < 0.05; **: P < 0.01; ANOVA: Analysis of Variance; Means between the classes of the same line followed by different letters differ significantly at the threshold of 5%.

The chroma of the thigh muscle was higher in transported chickens and lower in the chased one (P <0.01) on the slaughter day.

However, no difference was found for the three groups later. In the breast meat, it was higher with chased chickens and similar for the others flocks (P < 0.001).

The variation of color by sex for the three groups is presented in table 6. In the thigh muscle the yellow index in females of control and chased chicken was higher than the one of their correspondent males on the slaughter day (P <0.05). But at 24 hours *post mortem*, this difference was not significant. The hue angle was for the chased chickens higher on the slaughter day (P <0.05) in males but similar later.

The lightness, the red index, and the chroma didn't vary on the other hand from males to females of flocks on the slaughter day as well as at 24 hours *post mortem*.

In the breast meat, the red index a^* was higher in the males than in the females of chased chickens on the first day and of both stressed birds on the second day (P <0.001). The chroma was so in these males and females on the slaughter day (P <0.05), but it became identical the following day. The yellow index b * was more important in females (6.95) than in their homologue males (5.79) of the transported chickens at 24 hours *post mortem* (P <0.01). The other color components were similar from males to females at the measures times for the groups.

Table 5. Color of the *Pectoralis major* and of the *Iliotibialis superficalis* muscles of indigenous chicken according to the pre-slaughter stress.

Moment	Muscle	Variable	Control birds	Chased birds	Transported birds	Standard Error	ANOVA
Slaughter day	Thigh	L*	41.92a	43.16a	39.56b	0.66	***
		a*	15.25a	13.75b	16.01a	0.42	***
		b*	8.32a	7.94a	8.01a	0.26	NS
		Hue angle	1.77b	1.60b	2.20a	0.14	**
		Chroma	17.63a	16.22b	18.15a	0.39	**
	Breast	L*	52.96a	53.63a	47.92b	0.54	***
		a*	4.01b	5.34a	4.80a	0.25	**
		b*	6.34b	7.02a	5.64c	0.18	***
		Hue angle	0.21a	0.11a	1.14a	0.38	NS
		Chroma	7.63b	8.95a	7.68b	0.26	***
24 hours after slaughter	Thigh	L*	42.81a	42.07ab	40.74b	0.62	*
		a*	14.36a	14.11a	13.90a	0.41	NS
		b*	9.32a	8.46b	8.11b	0.24	**
		Hue angle	1.33b	1.67a	1.60ab	0.10	*
		Chroma	17.44a	16.65a	16.32a	0.38	NS
	Breast	L*	51.45a	52.60a	47.62b	0.61	***
		a*	3.34c	5.28a	4.58b	0.21	***
		b*	6.77b	7.50a	6.37b	0.19	***
		Hue angle	0.92a	-0.12a	-0.02a	0.64	NS
		Chroma	7.67b	9.33a	8.15b	0.22	***

NS: $P > 0.05$; * : $P < 0.05$; **: $P < 0.01$ ***: $P < 0.001$; L* : lightness ; a* : red index ; b* : yellow index ; ANOVA : Analysis of Variance; Means of the same line followed by different letters differ significantly at the threshold of 5%.

Shear force and sensory analysis of the Pectoralis major

The shear force was the same for the different flocks of chickens (Table 1). It didn't even vary by sex with control and chased chickens. But the males transported showed a superior value than their homologue females (P <0.05) (Table 2). The flavor, the juiciness, the tenderness and the global acceptance of the breast meat didn't vary between the three groups of local chickens of South Ecotype of Benin (Table 1).

These parameters were also similar from the males to the females of the flocks (Table 2).

Discussion

Carcass traits of indigenous chicken according to the pre-slaughter stress

The live weight, the hot carcass weight, the breast weight, the thigh-drumstick weight, the wings weight, the hot carcass yield, the breast yield and the wings yield were similar for the birds of the three flocks.

The similarity observed between most of the carcass parameters shows that the experimental flocks are homogenous. The weight and the yield results of the current study are close to those recorded by Youssao *et al.,* (2009).The non-existence of significant difference between weight and yield parameters according to the stress in the present study could be explained by the short stress duration and the immediate slaughter of birds after the process. Otherwise, the immune reaction could result in reduction of feed intake, growth disturbance and weight loss. As example, Sohail *et al.*, (2012) recorded in broiler exposed to chronic heat stress a reduction of 16.4% of feed intake, of 32.6% of body weight and an increasing of feed conversion ratio of 25.6%.

Table 6. Color of the *Pectoralis major* and of the *Iliotibialis superficalis* muscles of males and females of indigenous chicken according to the pre-slaughter stress.

Moment	Muscle	Variable	Control birds		Chased birds		Transported birds		Standard Error	ANOVA
			Female	Male	Female	Male	Female	Male		
Slaughter day	Thigh	L*	42.50a	41.33a	43.07a	43.25a	39.39a	39.73a	0.95	NS
		a*	14.89a	15.61a	13.32a	14.18a	15.36a	16.66a	0.6	NS
		b*	8.99a	7.65b	8.72a	7.16b	7.97a	8.06a	0.36	*
		Hue angle	1.52a	2.01a	1.33b	1.86a	2.40a	2.00a	0.19	*
		Chroma	17.72a	17.53a	16.40a	16.03a	17.73a	18.57a	0.56	NS
	Breast	L*	53.63a	52.29a	53.74a	53.53a	48.04a	47.8a	0.77	NS
		a*	4.02a	4.00a	4.70b	5.99a	3.15b	6.45a	0.33	***
		b*	6.33a	6.35a	6.63a	7.40a	5.69a	5.58a	0.26	NS
		Hue angle	0.31a	0.11a	-0.003a	0.23a	1.61a	0.67a	0.54	NS
		Chroma	7.58a	7.68a	8.18b	9.72a	6.59b	8.77a	0.36	*
24 hours after slaughter	Thigh	L*	41.82a	43.89a	42.28a	41.85a	40.33a	41.15a	0.88	NS
		a*	15.04a	13.68a	14.09a	14.12a	13.50a	14.31a	0.58	NS
		b*	9.60a	9.03a	8.90a	8.02a	8.11a	8.10ba	0.34	NS
		Hue angle	1.30a	1.35a	1.75a	1.60a	1.58a	1.63a	0.14	NS
		Chroma	18.23a	16.64a	16.97a	16.33a	16.04a	16.59a	0.54	NS
	Breast	L*	52.39a	50.51a	52.47a	52.74a	49.24a	46.00a	0.85	NS
		a*	3.30a	3.38a	4.31b	6.25a	3.35b	5.82a	0.27	***
		b*	6.48a	7.07a	7.40a	7.60a	6.95a	5.79b	0.26	**
		Hue angle	0.87a	0.97a	-0.67a	0.43a	-0.72a	0.68a	0.91	NS
		Chroma	7.34a	7.99a	8.69a	9.97a	7.88a	8.41a	0.31	NS

NS: P > 0.05 ; *: P < 0.05 ; **: P < 0.01 ; *** : P < 0.001 ; L* : lightness ; a* : red index ; b* : yellow index;; ANOVA : Analysis of Variance; Means between the classes of the same line followed by different letters differ significantly at the threshold of 5%.

Variation of pH, of drip loss and of cooking loss

The pH of the breast and of the thigh muscles of chickens stressed by the transportation or by the capture chase was higher than the one of non-stressed chickens at all measure times. The muscle acidification was then lower with the stressed chickens. Their glycogen stock level could be lower. They could have certainly use part of their reserve of glycogen to produce energy during the physical activities endured in the stress process. According to Berri (2015), the ultimate pH depends on the glycogen concentration of the muscles at the slaughter time. Animal's disturbance lead to the depletion of muscle glycogen content and then to a high meat pH (Cartier and Moëvi, 2007).

The wings flapping duration on the slaughter line is negatively correlated to the muscle glycogen potential (Berri *et al.*, 2005).

The results of the current study are similar to those of other authors. Gigaud *et al.* (2007) observed with the free-range chicken that as for the transportation duration, a long waiting time (superior to 4 hours) results in highest pHu. Longer is the transportation duration, higher is the pHu (Gigaud *et al.*, 2007). Berri *et al.*, (2005) studying the effect of the activity on the slaughter line recorded that the increasing of the wings flapping duration provokes a higher pHu in broilers. Debut *et al.*, (2003) noticed that the thigh pHu is one of the main parameters influenced by pre-slaughter stress conditions. They observed that a two hours of transportation leads to a higher ultimate pH (6.21). But, they remarked no difference in the breast meat pH of transported and control chickens.

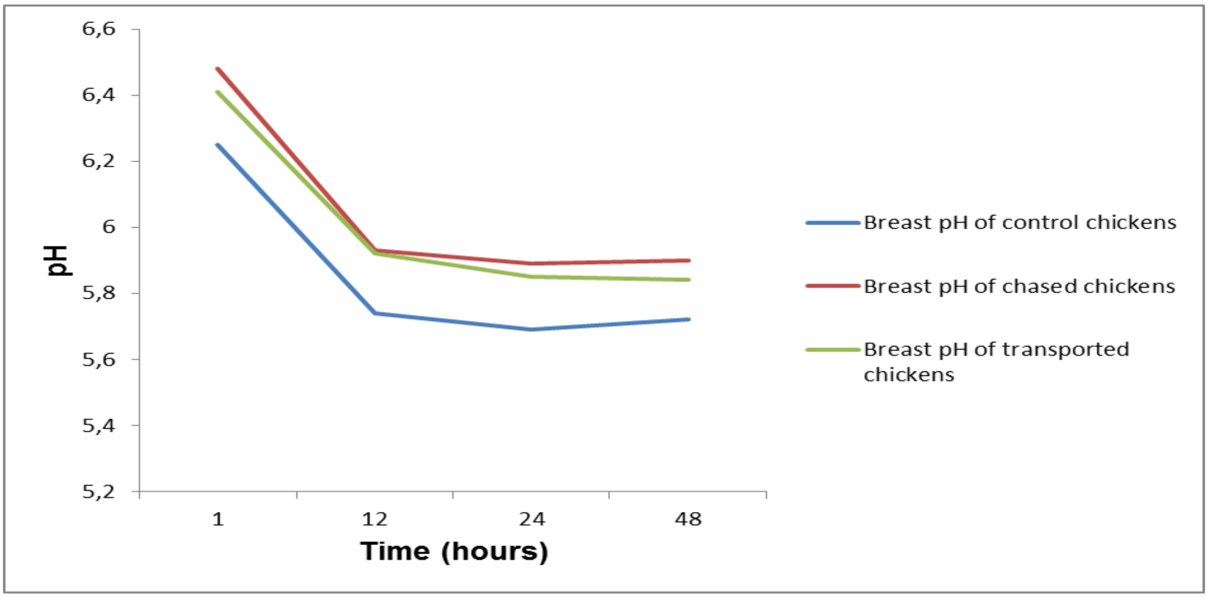

Fig. 1. Breast meat pH fall according to the stress during the 48 hours *post-mortem*.

The pHu usually observed in chicken meat is around 5.8 (Gigaud *et al.*, 2007). The pH48 of the breast of the transported chickens (5.84) and of the chased one (5.90) are not too superior to the normal.

These values of pHu are comparable to the normal value reported in the literature (Berri and Jehl, 2001; Quentin *et al.*, 2003; Debut *et al.*, 2003: Fanatico *et al.*, 2005). On the contrary, in the thigh of the transported (6.15) and of the chased (6.33) chickens, pH48 is relatively higher. So, the thigh meat of the local stressed chickens could be favorable to microbial proliferation and then, presents sanitary risks for the consumers.

Besides, from a sex to the other, males showed higher pH values than their homologues females at several measures times. The glycogen potential was therefore lower in males. They seem more sensitive to the stress than females. Schneider *et al.*, (2012) reported an ultimate breast pH in the males higher than the one in the females (5.96 vs 5.87).In the two muscles, and for the different flocks, the most important pH fall occurred in the first twelve hours *post mortem*.

During this period, the muscle glycogen was more available for anaerobic glycolysis reactions that take place in meat maturation process.

The drip loss was statistically similar for the three groups of chickens. On the other hand, Berri *et al.*, (2005), studying the effect of the stress of the activity on the slaughter line preceded or not by heat exposure, found that drip loss was more important in the stressed chickens of which pHu was relatively lower.

Schneider *et al.*, (2012) and Zhang *et al.*, (2014) also reported lower drip loss when the pH was higher.

This relation is not clearly perceptible in the current study.

Drip loss and cooking loss didn't statistically vary by sex but females showed the important proportions. This tends to confirm the negative correlation that exists between meat pH and meat drip loss. In the study of Schneider *et al.*, (2012), the difference was evident. The drip loss of females (2.34) was significantly superior to the one of the males (1.99%).

Color of the Pectoralis major and of the Iliotibialis superficalis muscles

In the breast and thigh meat, the lightness was the same for the control and chased chickens at the two measure moments but the smallest with the transported birds.

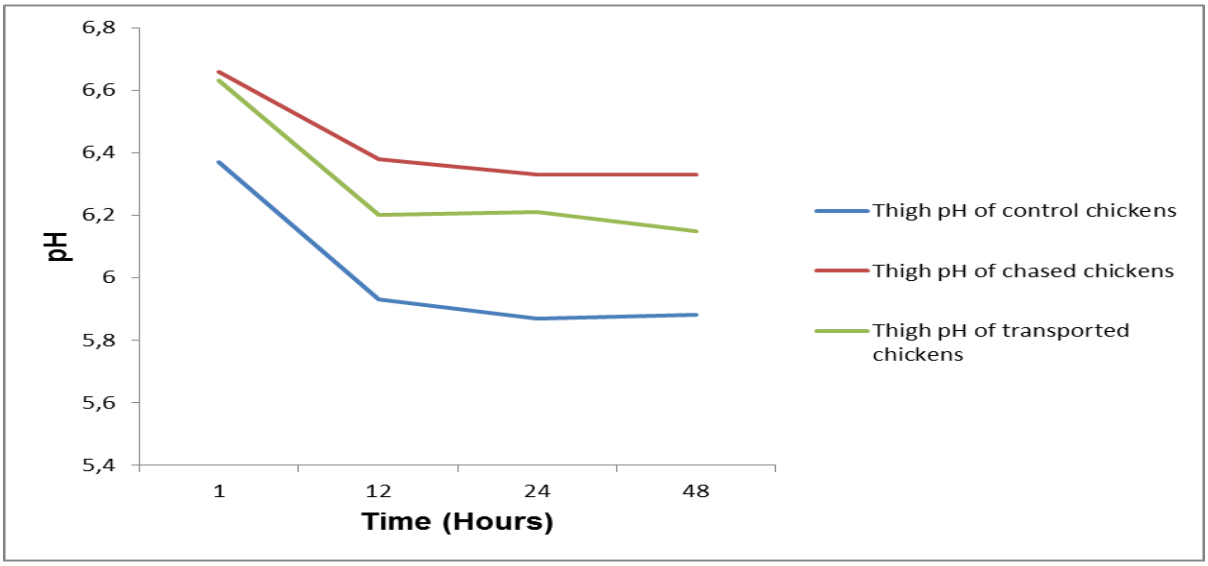

Fig. 2. Thigh meat pH fall according to the stress during the 48 hours *post-mortem*.

It was similar in the thigh of chased and transported chickens at 24 hours *post mortem*. The lower values observed in the transported chickens indicates that their muscles are darker. The thigh of the chased birds became dark at 24 hours *post mortem*. So the pre-slaughter stress conditions of the current study influence negatively the lightness of the local chicken's meat. The effect was more important with the transportation stress. A negative effect of stress on the meat lightness was also recorded by other authors in chickens. Gigaud *et al.*, (2007) observed that as for the transportation duration, a long waiting time (superior to 4 hours) results in a lower lightness. Debut *et al.*, (2003) observed a similar effect also after two hours of transportation but only in the thigh meat. On the contrary, high lightness was reported with other pre-slaughter stress factors. For example, the activity on the slaughter line was associated with high value of meat lightness (Berri *et al.*, 2005).

The red index a* was lower in the thigh of the chased chickens on the slaughter day but similar for the three flocks 24 hours after. The thigh was therefore less red with chased birds on the first day. In the breast it was lower with control chickens at the two moments. The high tendency of the red index in the breast of both stressed chickens indicates that the red color of the breast is influenced by stress and is more pronounced. Some similar results were found.

Indeed, Bianchi *et al.,* (2006) reported a significant effect of the transportation on poultry meat color. Birds transported on a short distance (<40 km) presented higher red index in the breast than (a * = 3.59) those transported on a long distance (40 to 210 km or more). The redder could be explained by an increasing of the hemoglobin rate due to an important blood influx in the muscle in activity. However Debut *et al.,* (2003) didn't observe a significant difference between the transported chickens and the control one.

The yellow index b * registered in the thigh was identical for stressed and control chickens on the slaughter day but lower with the stressed birds at 24 hours *post mortem*. Then, it's thinkable that the yellow index in the local chicken thigh is as well as the lightness negatively influenced by stress at 24 hour *post mortem*. But Debut *et al.,* (2003) didn't observe a significant difference between the transported chickens and the control one for this parameter in the thigh and breast muscles.

The analysis of the local chicken meat pH and color results of the current study reveals that higher pH is associated to lower lightness and to higher red index. A similar relation was described in several studies. Thus, Berri *et al.*, (2005), Gigaud *et al.*, (2006), Gigaud and Berri, (2007), Gigaud *et al.*, (2007 and 2008), Sheard *et al.*, (2012), Harford *et al.*, (2014) and Xing *et al.*, (2015) reported that the color of meat in poultry especially the lightness and the ultimate pH are in significant negative correlation. Harford *et al.*, (2014) observed that when the lightness and the yellow index increase, the red index decreases. Indeed, the selection for the increasing of the lightness resulted in an increasing of the yellow index.

In the thigh muscle the yellow index in females of control and chased chickens was higher than the one of their correspondent males on the slaughter day. Then, the higher values of the yellow index were found in the females. In the breast meat, the red index a^* was higher in the males than in the females of chased chickens on the first day and of both stressed birds on the second day. The yellow index b^* was more important in females (6.95) than in their homologue males (5.79) of the transported chickens at 24 *post mortem*. These results of red index and of yellow index observed among the transported males correspond to the relations described above between these parameters of color and the pH since the transported males have the pH24 and pH48 higher than those of their homologue females. Besides, the high red index of males in the current study is in conformity with other previous results. El Rammouz (2005) indicated that in poultry, the concentration of the myoglobin, pigment responsible for the red color, is more abundant in the breast and thigh muscles of the males than in those of the females.

Shear force and sensory analysis of the Pectoralis major of indigenous chicken according to the pre-slaughter stress

The shear force was the same for the different flocks of chickens. Birds having similar drip and cooking loss, these results show out a clear adequacy. The shear force didn't even vary by sex with control and chased chickens. But the males transported had higher value than their homologue females. The meat of the transported males was therefore harder than the one of the females of this group. Abdullah and Matarneh (2010) on the contrary observed this in the females.

The flavor, the juiciness, the tenderness and the global acceptance of the breast meat didn't vary between the three groups of local chickens. This tenderness confirms their shear force results. This non-existence of difference between sensory quality attributes according to the stress could be explained by the closeness of breast pH48 with the normal average value of chicken meat pH reported in the literature.

Moreover, this situation could be justified by the non-conservation of the meat used for the test during a long time. The analysis was done at 48 hours after slaughter. Otherwise, although the difference of the pH is not too higher, at that time, it could affect meat juiciness and tenderness which are directly in relationship with meat pH (Hocquette *et al.*, 2000; Geay *et al.*, 2002).

The marks given by the jury to the sensory meat attributes are around 3/5. Similar results were gotten by Youssao *et al.*, (2009) for the sensory quality of the local chicken. The flavor, the juiciness, the tenderness and the global acceptance of the breast meat were also similar from males to the females. So, the difference between the shear force of males and females transported didn't appear in the sensory analysis results.

Conclusion

The study reveals that pre-slaughter transportation and capture chase stress doesn't influence carcass quality but negatively affects meat quality of indigenous chicken reared under traditional system in Benin. Both stress factors lead to a low acidification degree of meat.

The phenomenon is pronounced in the thigh meat. Besides, meats of the local chickens stressed by the transportation and by the capture chase are redder and darker. The color defects are pronounced with the transported males. Finally male's meat seems to be redder and female's meat seems to be more yellow.

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